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Outcome Based Innovation Measurement Index

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Abstract
This paper combines the multidimensional nature of innovation in a single composite indicator based on outcome instead of inputs to capture the level the innovation in an economy. The indicators selected are intellectual property charges, patents, foreign direct investment and high technology exports which are innovation outcome characteristics of an economy. The method used for construction of composite indicator is geometric mean. This index is different from other existing indices of innovation in that it does not consider inputs as indicators of innovation which is methodologically flawed in the sense that inputs hardly get converted into outputs. The countries taken are those whose data are available in the public domain of the considered variable. The index is constructed for the year 2018. The rank correlation is calculated between the countries ranked with the outcome based innovation index and the index constructed by World Intellectual Property Rights Organization known as global innovation index which is also a measure of innovation but it includes inputs as well as outputs as indicators of innovation at macroeconomic level. The rank correlation between the two indices is found to be 0.92 which makes the outcome based innovation index a good measure of innovation at an economy level. The proposed measure of innovation duplicates the rankings of GII without the methodological flaws.

Keywords: Composite indicator, outcome based innovation measurement, geometric mean.

INTRODUCTION

The importance of innovation for socio-economic growth has already been established (OECD 1992). Technological progress and innovation are exclusive determinants of rising per capita income (Solow 1957). The ideas driven growth theory of Romer (1986, 1990, 1994) investigates back and concludes that technological advancements comes from new knowledge creation which occurs through R&D (Marr 2018). To substantiate these claims innovation must be quantified and to quantify innovation, it should be defined, for the management, evaluation of the already existing innovation system, formulation and implementation of the future innovation policies.

Innovation as an economics' word has undergone through a lot of change and development through time, beginning from Schumpeter (1939, 1942) who viewed it as certain specific actions of entrepreneurs: launching a new product, process; identifying a source of raw material, locating a new market, setting up a new organization. Ducker (1985) presented innovation as an opportunity occurring from changes in socio-economic conditions to entrepreneurs resulting in the growth of their enterprise. Innovation as the implementation of a new or significantly improved product (good or service), or process a new marketing method or a new organizational method in business practices, workplace organizations or external relations is defined by OECD. Innovation is the process of adding value to products, processes or any other functions of the firms with the help of new ideas resulting into

pecuniary benefits to the firm and increased satisfaction for the customers or other economic agents (Gault 2018).

While measuring innovation, indicators that reflect innovation process accurately in an economy is a matter of concern (Ernst 2001). It is easy to pick some indicators or one and use it to rate economies but those indicators may not actually reflect the true scenario of innovation in that economy or may not reflect anything related to innovation that matters (Oslo Manual 2018). Redundant and too simplistic indicators may produce ambiguous results (Ahuja & Katalia 2001). This paper quantifies the level of innovation in an economy on the basis of outcome measures of innovation. Eventually, innovation is value creation or addition and can be successfully quantified considering the value of outcomes in monetary aspects. The outcomes of innovation this paper combines have a large value adding potential and at the same time require highly skilled labor, cutting edge technology and substantial amount of R&D expenditure for their production. The measures such as export quality (high technology exports), competitive investment (net foreign direct investment outflow), knowledge intensive population (number of patents and intellectual property receipts) have been chosen to formulate an index to quantify innovation in a particular economy. Geometric mean method has been used to combine the multidimensional nature of indictors. The higher the score of formulated index, the more innovative that economy is considered.

REVIEW OF LITERATURE

The importance of innovation in fostering economic growth has long been established theoretically as well as empirically (Rogers & Greenhalgh 2010). Innovation is the basic tenet of the flourishing industrialization (Schumpeter 1939, UN 2019). It can be identified as introducing a new process of production, introduction of a new product, establishing a new market, acquiring a new source of raw material and launching a new firm in the industry (Schumpeter 1935). Solow (1956), measured innovation in terms of technical progress which occurs exogenously and attributed to it the long-run sustained economic growth in GDP per capita. However, Romer (1986, 1989, 1994) asserted that innovation is an endogenous process and the new ideas as technological progress originates from the research and development, when latter commercialized become innovation.

Empirically investigating and reporting that, the rise in the GDP per capita in the US economy from 1909-1949 was not associated with the rise in the factors of production but with technical change occurring exogenously Solow (1957). Measuring the growth in the output of the US economy from 1870-1950 reported only 15% increase in output associated with increase in labor and capital, remaining of the increase in output was associated with technical enhancement and innovation Abromovitz & Dieterlen (1958). R&D Intensity, physical and human capital expenditure, training expenditure may not be the direct measure of innovation but provide impetus to innovative activities (Oslo Manual 2010). R&D intensity (Dziallas & Blind 2018) and aggregate research and development successfully capture innovation in an economy (Jamoute & Pain 2005a, 2005b). Domestic patents (Rehman et. al. 2015), patents (Chen 2008) capture the innovation activity of an economy. Foreign Direct Investment Outflow reflects the innovative potential of an economy (Garcia-Herrero and Siu 2009). Innovation in an economy is reflected by the venture capital investment intensity (Kortum and Learner 1998; Jeng and Wells 2000; Romain and Van Pottlesberghe 2004). European Innovation Scoreboard captures innovation process in an economy by creating an index of innovation drivers, knowledge creators, entrepreneurship and output (Arundel & Smith 2013). The input-output method of measuring innovation is too

complicated to formulate policy as it cannot specifically clear which input is impacting the output and adding maximum value to the market. Some of the innovation indicators are based on employment in particular industries which may or may not capture innovation if combined with other input and output indicators, as former is impetus to the innovation while latter is actual innovation (Suriseti 2018).

GII (2020) measures innovation by formulating an index considering data on political environment, regulatory environment, and business environment, public and private infrastructure for innovation, market openness, public and private expenditure on human capital formation and knowledge creation. However, there are complications associated with the GII. There are some indicators which may be creative such as national feature films, printing and publishing, Wikipedia edits, but are not true innovation indicators as how much value these activities are creating is not specified. Some indicators are related to education attainment that may not be necessarily adding value to the market. The input and output sub-indices ratio calculated as innovation efficiency ratio of one economy may be high because of the higher score of input sub index at the same time having little score output sub-index which actually indicate or represent value addition.

METHODOLOGY

The indicators chosen are outcome based indicators of innovation. These indicators capture the multidimensional nature of innovation. The indicators selected are

1) Charges from intellectual property rights sale divided by services exports
2) Foreign direct investment outflow divided by total investment
3) High technology exports divided by manufactured exports
4) Patent share divided by population share.

All the above indicators require high intellectual skill, high research and development expenditure and cutting edge technology. They have the potential to add maximum value to the market.

The formula used for the combining the multidimensional nature of innovation is geometric mean and is as following.

$$OBII=\sqrt[4]{C*F*H*P}$$

Where,

OBII……. is outcome based innovation index,

C……. …is charges for the use of intellectual property over services exports,

F……. is foreign direct investment outflow over total investment

H……. is high technology exports over manufactured exports

P…….. is patent share over population share.

Country	C	F	P	H	OBII	nOBII	giirnk 19	OBIIrnk	giirnk cr	Correl
Australia	0.013959	1.000784	1.138567	0.181769	0.231882	0.269934	22	24	21	0.92117
Austria	0.017977	1	5.058251	0.116456	0.32123	0.379902	21	18	20	
Brazil	0.023333	1.006997	0.047703	0.147439	0.113376	0.124394	66	32	39	
Canada	0.059981	1.157107	1.847536	0.154219	0.374999	0.4457	17	16	17	
China	0.02381	1.023505	1.360146	0.315677	0.319831	0.377947	14	19	14	
Czechia	0.016279	1.08978	0.661717	0.195514	0.21888	0.253966	26	25	24	
Denmark	0.046067	1.083362	5.678557	0.12358	0.432602	0.516443	7	12	7	
Estonia	0.002064	1	0.524049	0.181715	0.118406	0.130572	24	31	22	
Finland	0.109011	1.045266	7.858141	0.090176	0.53306	0.639818	6	10	6	
France	0.058681	1.209021	3.796932	0.25917	0.514029	0.616446	16	11	16	
Germany	0.102553	1.224885	6.194353	0.157445	0.591618	0.711735	9	6	9	
Hong Kong SAR, China	0.006563	1.942819	0.773521	0.646526	0.28259	0.33221	13	20	13	
Hungary	0.062086	1	0.331582	0.168099	0.242543	0.283027	33	23	29	
India	0.00383	1.013061	0.031216	0.090404	0.057523	0.0558	52	37	35	
Indonesia	0.001961	1.01776	0.010428	0.082128	0.036158	0.029561	85	40	40	
Ireland	0.064552	1.86235	3.293403	0.248187	0.559885	0.672763	10	8	10	
Israel	0.024591	1.074361	4.259347	0.225359	0.399058	0.475247	11	14	11	
Italy	0.04014	1.099736	1.859962	0.074755	0.2799	0.328906	30	21	26	
Japan	0.234601	1.124255	11.32767	0.172692	0.847524	1.026019	15	1	15	
Korea, Rep.	0.074742	1.070374	12.9311	0.363907	0.783306	0.947151	12	3	12	
Luxembourg	0.017332	1	18.0579	0.069732	0.384357	0.457193	18	15	18	
Malaysia	0.0066	1.0672	0.1579	0.5311	0.1560	0.1768	35	29	30	

	26	41	85	4	77	36				
Mexico	0.000738	1.043659	0.046845	0.208886	0.052401	0.049509	56	38	37	
Netherlands	0.190904	1	6.699986	0.224915	0.732364	0.884588	4	4	4	
New Zealand	0.0411	1.01267	1.275394	0.098115	0.268641	0.315079	25	22	23	
Norway	0.014102	1.117465	3.527055	0.211173	0.32915	0.389391	19	17	19	
Pakistan	0.00118	1	0.000834	0.021698	0.012088	0	105	41	41	
Philippines	0.001148	1.043705	0.006685	0.613458	0.047084	0.042979	54	39	36	
Poland	0.009013	1.019175	0.529053	0.10394	0.149918	0.169272	39	30	31	
Portugal	0.00308	1.032804	0.247337	0.052834	0.080294	0.083765	32	34	28	
Russian Federation	0.013552	1.086377	0.826956	0.113187	0.192672	0.22178	46	26	33	
Singapore	0.042799	1.237182	2.992638	0.515636	0.534646	0.641766	8	9	8	
Slovenia	0.007618	1.039024	1.302057	0.068251	0.162857	0.185163	31	28	27	
South Africa	0.010686	1.060136	0.126261	0.052719	0.093186	0.099598	63	33	38	
Spain	0.016266	1.130979	0.677621	0.067665	0.170421	0.194453	29	27	25	
Sweden	0.104337	1.088636	8.34316	0.141597	0.605238	0.728462	2	5	2	
Switzerland	0.225784	1	15.50654	0.133175	0.826338	1	1	2	1	
Thailand	0.002104	1.135899	0.025346	0.237003	0.061555	0.060752	43	36	32	
Turkiye	0.002849	1.015698	0.227414	0.026735	0.064762	0.06469	49	35	34	
United Kingdom	0.060412	1	2.011902	0.223196	0.40584	0.483576	5	13	5	
United States	0.133244	1	4.472588	0.184741	0.576026	0.692586	3	7	3	

Where,
OBII……. is outcome based innovation index,
C……. …is charges for the use of intellectual property over services exports,
F……. is foreign direct investment outflow over total investment
H……. is high technology exports over manufactured exports
P…….. is patent share over population share.
Nobii …. is the normalized score of the outcome based innovation index.
The formula used for normalization in max-min normalization (Xi – Xmin / Xmax - Xmin) also known as range normalization, where Xi is the value of the index, Xmin is the minimum value of the index and Xmax is the maximum value of the index.
Giirnk19…….. is the ranking of the countries based on the global innovation index,
OBIIrnk……is the ranking of the countries based on the outcome based innovation index.
Giirnkcr…….is the ranking of the countries modified to calculate the rank correlation between the two indices.
Correl……is the correlation between the rankings of the countries based on outcome based innovation index and global innovation index.

CONCLISION

The rank correlation between the rankings of GII(Global innovation index) and OBII(Outcome based innovation index) is 0.92, which is high enough to conclude that the proposed index is reliable and robust. The outcome based innovation index has the edge that it directly measures innovation with the help of economic outcomes and does not consider inputs as components of an innovation index. So, OBII innovation index is a step improved composite indicator when it comes to measuring innovation at macroeconomic level.

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